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16. Abstract

Since 1964, all air carriers have been required by regulation to conduct continuous evaluations of their maintenance programs. Specifically, Title 14 Code of Federal Regulations (CFR) Parts 121.373 and 135.431 require air carriers to establish a Continuing Analysis and Surveillance System (CASS) to evaluate, analyze, and correct deficiencies in the performance and effectiveness of their inspection and maintenance programs. While the regulation governing CASS is short, its sparse language nonetheless requires a complex system. Each CASS must set high goals, and the Federal Aviation Administration (FAA) is empowered by the regulations to require changes to an air carrier's maintenance program if it shows signs of weakness.

To assist industry maintenance personnel and FAA inspectors to understand and comply with CASS requirement, this report proposes three models that illustrate how the structure of CASS can be established based on an air carrier's size and complexity. Each model represents a complete system that should meet, or exceed, the regulatory requirements, and on which new entrant air carriers can base their CASS. Existing air carriers can also use the models as a comparison to their existing CASS and determine its effectiveness.

The results in this report are based on the information gathered through research and on-site interviews with industry, FAA, and trade association representatives. Interviews of eighteen 14 CFR Part 121 air carriers, five 14 CFR Part 135 air carriers, four aviation industry associations, and a representative of the Joint Aviation Authorities of Europe were conducted over a 6-month period. Interviews of personnel at the FAA Flight Standards District Office, Certificate Management Office, and Headquarters were also conducted to gain input from the regulatory perspective.

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GLOSSARY OF TERMS

CFR	Code of Federal Regulations
AC	Advisory Circular
ACARS	Aircraft Communications Addressing and Reporting Systems
ASRS	Aviation Safety Reporting System
CAMP	Continuous Airworthiness Maintenance Program
C.A.S.E.	Coordinating Agencies for Supplier's Evaluation
CASS	Continuing Analysis and Surveillance System
CDL	Configuration Deviation List
CRB	CASS Review Board
ETOPS	Extended-Range Twin-Engine Operations
FAA	Federal Aviation Administration
MEL	Minimum Equipment List
MIS	Mechanical Interruption Summary
MRR	Mechanical Reliability Report
OEM	Original Equipment Manufacturer
QA	Quality Assurance
QC	Quality Control
RII	Required Inspection Item
RVSM	Reduced Vertical Separation Minimums
SAI	Safety Attribute Inspection
SB	Service Bulletin
SUP	Suspected Unapproved Part
VDRP	Voluntary Disclosure Reporting Program
VP	Vice President

EXECUTIVE SUMMARY

Since 1964, all air carriers have been required by regulation to conduct continuous evaluations of their maintenance programs. Specifically, Title 14 Code of Federal Regulations (CFR) Parts 121.373 and 135.431 require air carriers to establish a Continuing Analysis and Surveillance System (CASS) to evaluate, analyze, and correct deficiencies in the performance and effectiveness of their inspection and maintenance programs. These regulations do not distinguish between maintenance functions the air carrier accomplishes and those that it contracts out. Nevertheless, the responsibility for CASS remains with the air carrier.

CASS is an air carrier quality assurance system, and must consist of the following functions: surveillance, controls, analysis, corrective action, and follow-up. Together, these functions form a closed-loop system that allows the air carrier to monitor the quality of its maintenance. In a structured and methodical manner, CASS provides air carriers with the necessary information to make decisions and reach their maintenance program objectives. Furthermore, if CASS is used properly, it becomes an inherent part of the air carrier's way of doing business and helps promote a safety culture within the company.

While the regulation governing CASS is short, its sparse language nonetheless requires a complex system. Each CASS must set high goals, and the Federal Aviation Administration (FAA) is empowered by the regulations to require changes to an air carrier's maintenance program if it shows signs of weakness.

To assist industry maintenance personnel and FAA inspectors to understand and comply with CASS requirement, this research proposes three models that illustrate how the structure of CASS can be established based on an air carrier's size and complexity. Each model represents a complete system that should meet, or exceed, the regulatory requirements, and on which new entrant air carriers can base their CASS. Existing air carriers can also use the models as a comparison to their existing CASS and determine its effectiveness.

The results in this report are based on the information gathered through research and on-site interviews with industry, FAA, and trade association representatives. Interviews of eighteen 14 CFR Part 121 air carriers, five 14 CFR Part 135 air carriers, four aviation industry associations, and a representative of the Joint Aviation Authorities of Europe were conducted over a 6-month period. Interviews of personnel at the FAA Flight Standards District Office, Certificate Management Office, and Headquarters were also conducted to gain input from the regulatory perspective.

1. FUNDAMENTALS OF CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM.

1.1 INTRODUCTION.

In response to a joint study conducted by the Federal Aviation Administration (FAA) and the National Transportation Safety Board related to a series of maintenance-related accidents and incidents, the FAA introduced regulatory requirements in 1964 mandating that air carriers establish and maintain a Continuing Analysis and Surveillance System (CASS). This would provide a structured process for monitoring the performance and effectiveness of their inspection, maintenance, preventive maintenance, and alterations programs. The CASS ensures a means to correct any deficiency in those programs, regardless of whether the programs are carried out by the air carrier itself or by any other entity (Title 14 Code of Federal Aviation Regulations (CFR), Parts 121.373 and 135.431.)

While the regulation governing CASS is short, this sparse language nonetheless requires a complex system. Each CASS must set high goals. The FAA is empowered by the regulations to require changes to an air carrier's maintenance program if it shows signs of weakness.

The regulation can be summarized as a requirement for air carriers to establish and use a system for the continuing analysis and surveillance of the performance and effectiveness of their programs. These emphasized words, which are taken directly from the regulation, form the core of what a CASS must address.

1.2 CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM CHARACTERISTICS.

CASS is an air carrier quality assurance system. In a structured and methodical manner, CASS provides air carriers with the necessary information needed to make decisions and reach their maintenance program objectives. Furthermore, if CASS is used properly, it becomes an inherent part of the air carrier's way of doing business and helps promote a safety culture within the company.

CASS monitors various programs, primarily the air carrier's Continuous Airworthiness Maintenance Programs (CAMP), which includes inspection. All air carriers have a CAMP to ensure that their aircraft are properly maintained. The primary function of CASS is to ensure that each air carrier's CAMP is effective. A working CAMP prevents premature failures while increasing aircraft and parts reliability and overall safety. In an ideal world, the air carrier's CAMP would ensure that there were no events between scheduled aircraft checks. In reality, each CAMP must be continually adjusted to move towards this ideal. An effective CASS should identify elements that are detrimental to the overall effectiveness of the air carrier's CAMP and correct those deficiencies before they become systemic problems.

1.3 DATA COLLECTION.

To achieve these goals, the CASS collects data and analyzes that data from several elements of an air carrier's CAMP. These data can be classified into routine, audit, and other data, depending on their source.

1.3.1 Routine Data.

Routine data is that which may or may not be required by the regulations but is collected on a regular basis by air carriers, through sources such as:

- Aircraft inspections
- Scheduled maintenance
- Required Inspection Item (RII) program
- Aircraft, engine, propeller, and appliance overhaul
- Major repairs and alterations
- Reliability program (if applicable)
- Structural inspection program (if applicable)
- Mechanical reliability reports (if applicable)
- Special Federal Aviation Regulation 36 authority (if applicable)
- Special operations (i.e., Category II, Category III, Minimal Navigation Performance Specification, Reduced Vertical Separation Minimums (RVSM), extended-range twin-engine operations (ETOPS))
- Aging aircraft issues, such as Corrosion Prevention and Control Programs, Supplemental Structural Inspection Documents, Structural Inspection Document, and structural repair assessments
- Nondestructive testing

1.3.2 Surveillance Data.

Surveillance/audit data is collected during CASS audits, from sources such as:

- Airworthiness responsibilities
- Maintenance manuals
- Maintenance organization and staffing
- Maintenance training
- Airworthiness Directive (AD) compliance

- Service Bulletin compliance
- Vendor facilities, capabilities, and performance including parts information such as excessive usage
- Equipment, facilities, test/measurement equipment calibration
- Fueling
- Weight and balance
- Baggage and cargo
- Records and reporting system
- Parts/material control, including Suspected Unapproved Parts (SUPs)
- Coordinating Agencies for Supplier's Evaluation (C.A.S.E.)
- Maintenance personnel duty time

1.3.3 Other Data.

Other data can be generated as a result of incidents or accidents, special investigations, special audits, or teardown analysis and are the result of an abnormality in the air carrier's operation. This data can come from the following sources:

- Unscheduled maintenance, including repetitive nonroutine maintenance
- Deferred maintenance (Minimum Equipment Lists (MELs), Aircraft Communications Addressing and Reporting Systems (ACARS), and Configuration Deviation List (CDLs))
- Teardown reports
- Mechanical interruption summary reports
- Parts/material control, including SUPs

1.4 CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM AS A CLOSED-LOOP SYSTEM.

Each CASS monitors the effectiveness and performance of its key elements. These key elements (audits, data collection, analysis, reporting, corrective action, and verification) are processes or programs that air carriers use to achieve particular goals. Some of these elements are required by 14 CFR, while others have been developed by industry or in partnership with the FAA to enhance the efficiency and/or safety of air carrier operations

Therefore, CASS is a closed-loop system review of interrelated elements, programs, and processes, including people, procedures, materials, tools, equipment, operational norms, facilities and, as applicable, information technology. This system provides for self-evaluation feedback within itself so that each air carrier's CAMP can keep up with changes at the air carrier. Examples that justify a need for changes include fleet or route system growth, aging of fleets, route changes, and systemic concerns identified through CASS (such as a deterioration of elements), and increased reliance on contracted maintenance. It is important to note that the regulations governing CASS do not distinguish between those maintenance functions the air carrier performs and those that it contracts out. However, the responsibility for CASS remains with the air carrier.

The complexity and sophistication of the CASS at each air carrier should be appropriate to its size and type of operation, and should also provide a means to accommodate the following objectives:

- Realize the levels of safety and mechanical reliability the air carrier has set.

- Restore the levels of safety and reliability that the air carrier has set in the event deterioration occurs.

- Collect the information necessary to identify systemic or other maintenance error contributors that degrade airworthiness and the level of safety and reliability that the air carrier has set.

- Collect the information the air carrier needs to continuously validate that all elements of the air carrier's maintenance program are being executed in accordance with the air carrier's manual.

- Collect the information the air carrier needs to continuously validate the effectiveness of each element of the air carrier's maintenance program. In other words, that the goals and objectives specified by the regulations are being met.

- Collect the information the air carrier needs to continuously validate the appropriate completion of each scheduled maintenance task and the adequacy of its associated interval.

- Compile the information the air carrier needs to improve the design of items whose level of safety and reliability proves inadequate.

1.5 CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM FUNCTIONS.

At a minimum, each CASS should contain the following functions.

1.5.1 Surveillance.

This function includes audits of suppliers, subcontractors, and internal airline elements to identify factors that could lead to an accident or incident or a breakdown in maintenance processes. The collected surveillance data is used in the analysis process.

The surveillance function of the CASS interfaces with all audited departments should preferably be established as a partnership for safety rather than a policing program that seeks to assign blame and punish those who make mistakes. It is generally accepted that complex systems will always include errors and deficiencies. The purpose of any CASS is to manage risk by identifying those shortfalls proactively (before they occur) and taking corrective action. The evaluation of the corrective action determines the effectiveness of the intervention. As in any other system safety approach, this process requires effective cooperation, coordination, and communication between relevant parties.

The system safety discipline is the application of special technical and managerial skills to the systematic forward-looking identification and control of hazards throughout the life cycle of a project, program, or activity. Rather than taking accidents or incidents and working back to find their causes, the system safety approach is proactive in reducing hazards by identifying, analyzing, assessing, prioritizing, documenting risks, and take proper action.

1.5.2 Controls.

Controls are checks and restraints designed into a process to ensure a desired result. Controls should be written into the air carrier's manual system to ensure that the manual procedures will be followed.

Controls may be in the form of administrative controls, which are secondary or supplemental written procedures that are put in place to ensure compliance with more important primary procedures. Like written procedures, administrative controls also need to provide answers to questions, such as who, what, when, where, and how, associated with the process. Controls may also be in the form of engineered controls, such as automated features or mechanical actions that are put into place to ensure compliance with the more important primary procedures. Controls should be implemented where a risk analysis has been performed. The purpose is to indicate that the likelihood and severity of a hazard, resulting from failure to comply with particular procedures, is sufficiently high.

1.5.3 Analysis.

This function consists of analyzing collected mechanical performance data and the results of the surveillance audits. All of this data is evaluated to be used as indicators to measure the degree of maintenance program effectiveness and performance at the air carrier. CASS looks for precursors, indicators, or symptoms of discrepancies in the air carrier's maintenance program to allow the air carrier to develop and implement corrective action.

Generally, air carriers collect and analyze the following operational performance data, as a minimum:

- Mechanical Interruption Summaries (MIS), which includes delays and cancellations (for example, in-flight turn-back)
- Maintenance Reliability Reports (MRRs)
- Pilot write-ups in aircraft logbooks
- Minimum Equipment List (MEL) items such as deferrals
- Nonroutine maintenance tasks, including those when an aircraft comes right out of a heavy maintenance check
- Unscheduled landings due to maintenance
- Vendor teardown reports

1.5.4 Corrective Action.

This function of CASS involves the development, implementation, and monitoring of corrective actions to deficiencies identified as a result of analysis. This also involves a review of the comprehensive fix to ensure that the problem does not recur in the future.

1.5.5 Follow-Up.

Follow-up is required to ensure that the air carrier's corrective actions have been acted upon. The air carrier's measurement of the effectiveness of its corrective actions permits the air carrier to evaluate the effectiveness of its CASS. The end result is a closed loop forming a continuous cycle of surveillance, investigations, data collection and analysis, corrective action, corrective action monitoring, and back to surveillance. As long as this process is effective, little external action is required. The effectiveness of CASS is shown by a review of each air carrier's actions in identifying, analyzing, correcting, and reviewing the changes brought about by the air carrier's own performance of CASS functions.

1.5.6 Benefits of CASS.

Benefits of an effective CASS include continuously improved, safer operations, increased maintenance efficiency; increased aircraft dispatch reliability; and reduced maintenance and operational systemic errors. A fully functioning CASS allows air carriers to ensure the safety and stability of their maintenance program.

A properly functioning CASS also proves useful for special programs, such as ETOPS, RVSM, and Category II and III approach approvals because of the more rigorous standards these programs require. Such higher-level requirements sometimes present complications for air

carriers and result in the splitting of fleets between ETOPS and non-ETOPS aircraft, for example. Through its CASS, an air carrier may find that it is more economically sound to apply ETOPS-level standards to an entire fleet rather than applying two separate maintenance programs to a single fleet of aircraft. To determine how an entire fleet's reliability can be improved, CASS may also be able to identify problems in the non-ETOPS segment of the fleet and compare them to the ETOPS segment of the fleet.

2. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM FUNCTIONAL AREAS.

2.1 SURVEILLANCE.

The surveillance function of CASS includes both internal and external audits through which the air carrier ensures that its CAMP is adequate and is working properly. These audits can be further divided between scheduled and unscheduled surveillance. Scheduled surveillance is proactive and represents a constant monitoring of the air carrier's maintenance processes. Unscheduled surveillance is reactive and arises from particular events, such as incidents or in-service equipment failures. Ideally, corrections to the air carrier's CAMP can be made on a proactive basis by using a program that discovers latent failures.

As with any critical safety process, there should be one person identified by the air carrier who is responsible for the CASS surveillance process. This individual should be a senior manager, such as a Vice President (VP) of Maintenance. In larger organizations, these senior managers normally delegate the authority to implement and maintain CASS surveillance to other managers, such as a Chief Inspector or a director of quality assurance.

The surveillance function should have written procedures to ensure standardization and uniformity across surveillance activities. Many air carriers include these procedures in their General Procedures Manual, in a dedicated CASS manual, or in a section of a Maintenance Policy and Procedures Manual, which itself may be supplemented with a quality department procedure manual.

Air carrier surveillance personnel should establish a schedule for the air carrier's surveillance process to ensure that all necessary areas are addressed. These surveillance areas include, but should not be limited to, the following items:

- All manuals, publications, and forms. These must be useable, current, accurate, and readily available to their users.

- All maintenance and alterations. These must be performed in accordance with the methods, standards, and techniques specified in the air carrier's manuals.

- Maintenance records. These must be generated in accordance with the air carrier's manual procedures and are adequate, correct, and complete.

- Required Inspection Items (RII)s. These must be clearly identified and handled in accordance with the air carrier's RII procedures.

- Airworthiness releases. These must be executed by authorized persons and accomplished in accordance with the procedures specified in the air carrier's manuals.

- Shift turnover records and deferred maintenance. These must be handled in accordance with the air carrier's manual procedures. Air carriers should consider focusing on shift turnover errors as part of their surveillance system.

- All maintenance facilities and equipment, including contract maintenance facilities and equipment. These should be adequate for the maintenance required.

- All personnel, including contract personnel. They must be competent to properly execute the maintenance that is to be performed and comply with the air carrier's procedures for recording maintenance.

- Airworthiness of aircraft. Each aircraft the air carrier releases into service is airworthy and properly maintained for service in air transportation.

2.2 CONTROLS.

Although CASS is responsible for the continuing effectiveness of the air carrier's programs, CASS itself should be evaluated through outside means, such as an Internal Evaluation Program (IEP). IEPs are not mandatory, but can effectively ensure that CASS is accomplishing what is intended. For this process to be effective, the individuals responsible for CASS must be open to the scrutiny of their activities by an external review.

The air carrier should also ensure that the data collected by CASS is useful from a System Safety perspective. The person or organization responsible for data collection and analysis should have proper controls in place to measure the effectiveness of the data the air carrier collects and to modify its procedures and requirements based on its own internal evaluations.

2.3 ANALYSIS.

The analysis function of CASS is the means through which each air carrier can monitor the effectiveness of its maintenance programs, and includes analysis of surveillance results as well as mechanical performance data. The purpose of the data analysis is to identify shortfalls in the air carrier's processes. The evaluation of this data aids the operator in developing corrective actions and follow-up plans.

An air carrier's surveillance elements will generate a tremendous amount of data, which must be organized and analyzed in order to be useful. The air carrier should have a mechanism in place to continually tailor its surveillance activities to ensure that those activities are timely and targeted appropriately. Otherwise, the air carrier is expending resources with little benefit and negative trends may not be identified until it is too late. Such shortfalls in a surveillance system negate the advantages of having a CASS and do not meet the regulatory intent of the CASS.

2.4 SURVEILLANCE DATA ANALYSIS.

It is not sufficient to simply identify a problem through surveillance. Once a problem becomes known, it has to be evaluated through various types of analysis, including root cause analysis, risk analysis, and human factors investigations.

2.4.1 Root Cause Analysis.

The basic principle of root cause analysis, in simple terms, is that an auditor must continue investigating a finding until he/she arrives at an initial factor that may be changed to reduce the risk of producing safety problems in the future. After an audit, each finding that is identified as a root cause should be one that is being considered for action and addressed in the audit report.

Root cause analysis should cover the following areas:

Areas	Functions
Management responsibility	Organization or person who determines the course of action for a process, who owns the process, and who is accountable for the quality of the process.
Procedures	Documented or prescribed methods of accomplishing processes.
Controls	Checks or restraints that are designed into a process to ensure that a desired result is achieved.
Process management	Measures or information assessments to identify, analyze, and document potential problems with a process.
Interfaces	Interactions between independent processes.

The following is indicative of how a root cause analysis can be accomplished:

What happened?

- What are the details of the event?
- When did the event occur?
- What area and/or process were impacted?

Why did it happen?

- What were the most proximate factors?
- What systems and processes underlie those proximate factors?

Auditors perform this root cause analysis to uncover latent failures. For each finding identified in the analysis that requires an action, the auditor should indicate the planned expected action, its implementation date, and associated measure of effectiveness. If, after consideration of such a finding, a decision is made not to implement an associated corrective strategy, the auditor should indicate the rationale for not taking action.

Auditors should check to ensure that the selected measure would permit assessment of the effectiveness of the action and consider whether a pilot testing of a planned improvement should be conducted. Improvements should ultimately be implemented in all areas where applicable and not just limited to where the event occurred. An identification of areas where the improvements will be implemented should also be identified.

2.4.2 Risk Analysis.

Risk analysis (also known as risk management) includes consequence and likelihood ratings for the purpose of managing risk. This process starts by establishing the context for the risk picture at the air carrier. Hazards can be identified by reviewing incident history, audits, and studies, followed by the formation of a panel of experts to brainstorm over these hazards. The panel can then generate a list of potential hazards that can be validated through testing by including these areas into the audit process.

The next step in the process is to assess the risk of each identified hazard. The process shown below is a representative sample of how a risk analysis works. In this process, assessing the risk can be accomplished using the following steps:

- Identify existing defenses.
- Rate the effectiveness of existing defenses.
- Describe the worst-case scenario.
- Rate the consequences of each scenario. Consequences can be rated as follows:
  - Insignificant
  - Minor
  - Moderate
  - Major
  - Catastrophic
- Rate the likelihood of the consequence of each scenario. Likelihoods can be rated as follows:
  - Rare
  - Unlikely
  - Possible
  - Likely
  - Almost certain
- Based on consequence and likelihood ratings, assign a risk level to each hazard

Once this analysis has been accomplished, risks can be treated using the decision matrix shown in figure 1.

	Consequences				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain					
Likely					
Possible					
Unlikely					
Rare					

Key

Color	Risk Level	Evaluation	Response
	Extreme	Intolerable	Urgent action required
	High	Must consider measures to reduce risk	Improvement required in the short term
	Moderate	Must consider measures to reduce risk	Assess and monitor regularly
	Low	Tolerable	Assign a low risk priority

FIGURE 1. RISK RESPONSE MATRIX

Based on this matrix, the air carrier should determine appropriate actions and select actions based on a preference order, which is:

- Eliminate
- Substitute
- Engineer
- Procedures/training
- Protective equipment

The air carrier can then consider corrective action for urgent hazards and contemplate preventative actions for long-term risk management. Finally, the responsible manager should be presented with a timetable and the agreed action for approval.

2.4.3 Analysis Process.

Air carriers should track audit results and analyze them to identify any trends, particularly negative ones that may require changes to the air carrier's maintenance programs. Many air carriers have the auditors themselves perform the analysis of audit findings. In some instances, air carriers have a dedicated analysis section that provides statistical trending and determines causal factors for presentation to a management committee. Others leave the system analysis to a senior management level determination, which is often accomplished during weekly or monthly meetings in connection with reliability and audit report information review. Often this information is shared only within the maintenance organization and there is little interface with similar systems such as the Internal Evaluation Program (IEP), Voluntary Disclosure Reporting Program (VDRP), and Aviation Safety Reporting System (ASRS).

Programs such as IEP, VDRP, and ASRS overlap in their observations of maintenance and provide a different perspective on the overall functioning of the air carrier so that the exchange

of information is a necessary ingredient of a successful CASS. Some larger air carriers have safety committees or councils that coordinate the sharing of information between programs and are generally comprised of senior management representatives of all operational elements. Smaller air carriers (i.e., Part 135) may not have a formal council or board, but they should have a formal interface for a line of communication between the CASS responsible manager and his/her superiors. In this way, potential problems in the air carrier's maintenance program can be brought to the attention of senior management regardless of the complexity of its operation.

The analysis element should incorporate a means to identify mechanical and process failures as well as active versus latent (system) failures.

Mechanical performance analysis developed within a reliability program identifies active failures that are readily observed through failures of equipment, whereas surveillance analysis seeks to uncover process or system failures that contribute to the decay of mechanical reliability or create unairworthy or unsafe conditions. Reliability data elements coupled with CASS findings help to provide a more complete snapshot of the health of an air carrier's maintenance organization.

Some operators use a formal process, whereas others use an informal means for conducting this analysis. The analysis of audit results can be performed individually or entered into an automated system to identify the trends. Each one has advantages and disadvantages. A significant disadvantage to an automated system is the cost of developing what is often a customized system for the air carrier. However, an automated system provides more efficient tracking and makes it less likely for findings to languish with no action.

To be effective, air carriers should prioritize audit findings to ensure that critical ones, such as airworthiness or noncompliance issues, are corrected in an expeditious manner. If there is an airworthiness or safety issue, the air carrier should have a process to stop work, or recall work that has been performed and returned to service. Such findings should also trigger special audits, which are audits other than scheduled audits that are often initiated as a result of an airworthiness or safety issue.

Air carriers should have written procedures for the risk analysis of audit results. This should include analysis protocols or the use of tools such as the Boeing maintenance error decision aid or the Human Factors Analysis Classification System for Aviation Maintenance. This system was developed by the FAA in collaboration with the U.S. Navy for specific use in commercial aviation as a human factors data collection and analysis tool. Air carriers should make every effort to consider using automation in the analysis and tracking process for audit results.

2.4.4 Human Factors.

This term refers to elements that contribute to incidents and/or accidents that relate to the particularities of human behavior and how it relates to the working environment. Statistics show that 80 percent of accidents are due to human error. In the U.S., recent statistics indicate that 30 percent of recent accidents have featured maintenance human factors problems. Human factors problems may be latent and can contribute to aircraft failures.

One aspect of human factors is the study of how physical limitations and environmental factors affect human performance. Humans are fallible and understanding when and where humans are vulnerable to error will permit air carriers to recognize those factors that produce unfavorable results. The human factors discipline seeks to analyze how the physical setting and social environment in the workplace can affect human performance and potentially affect maintenance processes. An example of human factors analysis is the scrutiny of shift changeover procedures. It is quite easy for the continuity of maintenance to be broken during shift changeovers if adequate procedures are not in place.

While human factors analysis focuses on the reasons behind human error and how to minimize it, sometimes individuals simply forget to do something, and occasionally this can lead to a safety problem. An awareness of this phenomenon is important, but careful investigation is required to ensure that an error was not merely the result of a momentary human lapse, but rather a systemic problem that must be resolved.

2.5 PERFORMANCE DATA ANALYSIS.

Generally, mechanical performance data is analyzed by a reliability function within the air carrier's organization. While this function can be performed by an entire reliability department or by a single analyst, the purpose is the same: to monitor data generated by the air carrier for mandatory reporting purposes and to preserve the continued reliability of the air carrier's aircraft. In either case, the air carrier should describe in a relevant manual or in a section of a manual, who is responsible for the collection and analysis of performance data and who has the authority to make changes to this process. This documentation should also have detailed procedures on how the organization is structured, and it should include a description of the types of data that will be collected and analyzed.

As stated previously, air carriers collect and analyze the following minimum operational performance data:

- Mechanical Interruption Summary (MISs), including delays and cancellations
- MRRs
- Pilot write-ups in aircraft logbooks
- MEL, CDL, ACARS, items such as deferrals
- Nonroutine maintenance tasks, especially when an aircraft comes right out of a heavy maintenance check, flight log write-ups, and special inspections (i.e., heavy weight or hard landings)
- Unscheduled landings due to maintenance
- Vendor teardown reports

While this data represents a typical minimum list, many air carriers collect and analyze much more. However, too much data can overload the system, including the data analysts themselves. Therefore, simply collecting more data is not necessarily beneficial, and operators should ensure that they only collect meaningful, quality data, rather than large quantities of information.

Data analysis consists of comparing collected data to established aviation standards, identifying deficiencies, and determining trends and parameter shifts. For example, once the data is properly analyzed, the air carrier may want to make changes to its maintenance programs as a result.

Industry surveys have revealed that some confusion exists between the CASS and reliability programs. While a reliability function may be a part of a CASS, it cannot substitute for a CASS because reliability programs do not have an audit function and only look at performance data. Reliability programs can extend or reduce component and aircraft times without presenting a safety problem. However, such a change could present a safety problem if the change is not properly justified or implemented.

Performance data collection and analysis functions will normally interface with the original equipment manufacturer (OEM) of each aircraft, engine, and component to resolve reliability or quality issues, and for possible design considerations. Some air carriers have more complex organizations using their own engineering department to supplement the expertise of OEMs as well. However, smaller air carriers may use OEMs as their sole source of engineering support.

It is important for air carrier analysts to examine the reason behind mechanical failures using root cause analysis (similar in principle to the root cause analysis of surveillance data by auditors). Simply identifying that a particular component has failed a certain number of times does not constitute a proper analysis of the problem. For example, by investigating further, analysts may be able to determine why a particular component repeatedly failed. If other air carriers do not report similar failures, the problem may lie with the air carrier's own maintenance program. Perhaps improper training is the cause, or the company's maintenance procedures may be inadequate. Vendor or contractor performance may also be a consideration.

2.6 CORRECTIVE ACTION.

CASS ensures that the air carrier maintains the effectiveness of its programs through the development and implementation of corrective actions to findings identified as a result of surveillance and subsequent investigation and analysis. Company documents should describe who is responsible for the development of corrective actions, who has the authority to make changes to those procedures, and the steps involved in the development of corrective actions.

An important consideration with respect to corrective actions is that the auditing organization, or responsible entity, should not be tasked with the development of corrective actions. Normally, personnel from each affected department or shop are responsible for the investigation, evaluation of audit findings, and the development of responses to the findings to prevent a recurrence. At air carriers with a quality assurance (QA) organization, QA reviews and approves the resulting corrective action plans, and QA auditors are responsible for the approval of responses to these findings as well as ensuring their proper implementation. Under no circumstances should CASS

audits result in the transfer of the responsibility to achieve the desired outcomes from the operating organization to the auditing organization.

Written procedures should include a description of the role of auditors in developing responses to findings. The procedures should stress the importance of auditor independence and address the possibility that managers of the technical areas being audited may feel threatened by audit findings. One way to minimize this problem is to assign the development of corrective actions to the area responsible for implementing it.

As with other CASS functional areas, air carriers should measure whether their corrective actions are effective. This can be done through follow-up, as described below.

2.7 FOLLOW-UP.

Once corrective actions have been developed and implemented for audit findings, the air carrier should have a system in place to follow-up on the corrective actions to the findings, thus ensuring that the comprehensive fixes have been accomplished and are effective. In this manner, the air carrier can close the loop between the initial finding and the development and implementation of corrective actions.

The air carrier's procedures should describe the steps involved in the tracking of corrective actions, implementation schedules, and verification of adherence to proposed time limits, assignment of responsible individual(s), and subsequent follow-up. Depending on the complexity and size of the air carrier, tracking of follow-up action can be accomplished via an automated system or manually on paper. Generally, paper tracking of audit findings may lead to inefficiencies in monitoring corrective actions.

Air carriers should have procedures in place for follow-up. An example would be to establish a specified length of time for corrections. Findings may be categorized according to their severity, such as A, B, or C. Generally, a finding that could result in an immediate safety issue requires immediate action while another that could be a precursor to an event may be given more time for the implementation of a corrective action. Sometimes timelines for corrective actions can be delayed by the response time of manufacturers, which is normally outside the control of the air carrier. Because of this, alternative processes should be included in their manual that address such issues.

Each air carrier's system should have provisions to acknowledge that a corrective action may have unintended consequences and should provide a mechanism within follow-up procedures to guard against this. Air carriers should also describe what the appropriate levels of verification, through actual follow-up audits, are needed.

Generally, the following individuals or organizations would be responsible for ensuring that corrective actions have been properly implemented:

- Appropriate technical area manager
- Manager of quality audits

- QA auditor
- A person or group assigned by the CASS office or in the action plan
- An engineer that is assigned
- Reliability control board
- Maintenance director (mostly at smaller carriers)
- Accountable manager

Actions by management are also important when internal departments or external providers fail to complete corrective actions within the specified time frames. For example, there should be a requirement to notify senior management of the problem and corrective actions. It should also be an air carrier's policy to eventually require the temporary removal of vendors from vendor lists until the corrective action process is complete, or permanent removal if vendors persistently fail to complete the required corrective actions.

The following flowchart (figure 2) shows a generic CASS closed-loop system that depicts the surveillance process. This system applies to the CASS of any type of air carrier, regardless of size or complexity.

As shown in the flowchart, the air carrier's responsible manager is accountable for the entire CASS. The responsible manager delegates the CASS surveillance process to the air carrier's auditors who, in turn, develops an audit schedule and accomplishes the required surveillance.

During these audits, data is collected that can be divided into either individual findings or system findings. For example, an individual finding may be that a fire extinguisher was found to be empty during the audit of the main hangar of a maintenance base. The most likely explanation for this finding is that the fire extinguisher had been overlooked during the course of the maintenance personnel's regular checks of the hangar's fire protection equipment. An example of a system problem would be if numerous fire extinguishers were found to be empty during an audit, which could indicate a problem with the procedure used to ensure the extinguishers were in proper working order.

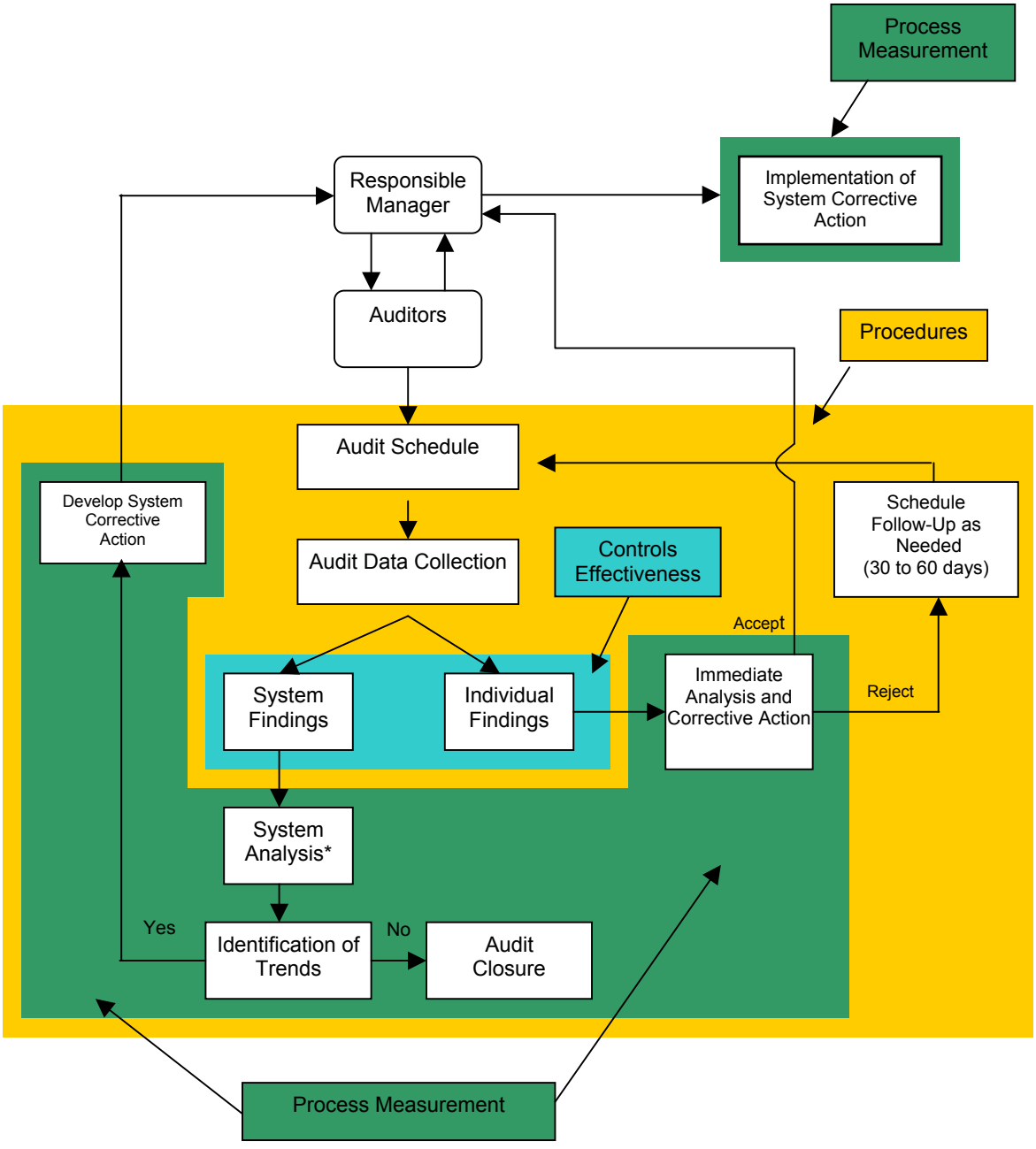
To resolve individual findings, auditors present them to the responsible managers for the affected area and an immediate corrective action is implemented based on analysis. If this action is accepted, the results are reported to the responsible manager (usually in a report that is compiled periodically); otherwise, a follow-up audit must be scheduled within 30 to 60 days to ensure that the corrective action was implemented.

For system findings, a system analysis may be required to determine the exact reasons for the findings. If a trend is identified, then system corrective action is required, which is reported to the CASS responsible manager. The responsible manager can then order the system corrective action to be implemented. If there is no identified trend, then the audit finding can be closed.

The diagram divides this process into three general groupings. The procedures section of the diagram (shaded in yellow) relates to the flow of CASS surveillance information. The controls effectiveness section (shaded in blue) describes the part of the CASS responsible for the system controls, which are primarily directed at identifying system problems versus individual findings.

Finally, the process measurement section (shaded in green) identifies the means through which CASS measures the effectiveness of corrective actions, and therefore, the effectiveness of CASS itself as a closed-loop system.

The CASS data analysis process flowchart shown in figure 3 is an amplification of the analysis functions within CASS and is a part of the overall CASS diagram shown in figure 2.



*See figure 3 for a more detailed description of system analysis

FIGURE 2. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM SURVEILLANCE PROCESS FLOWCHART

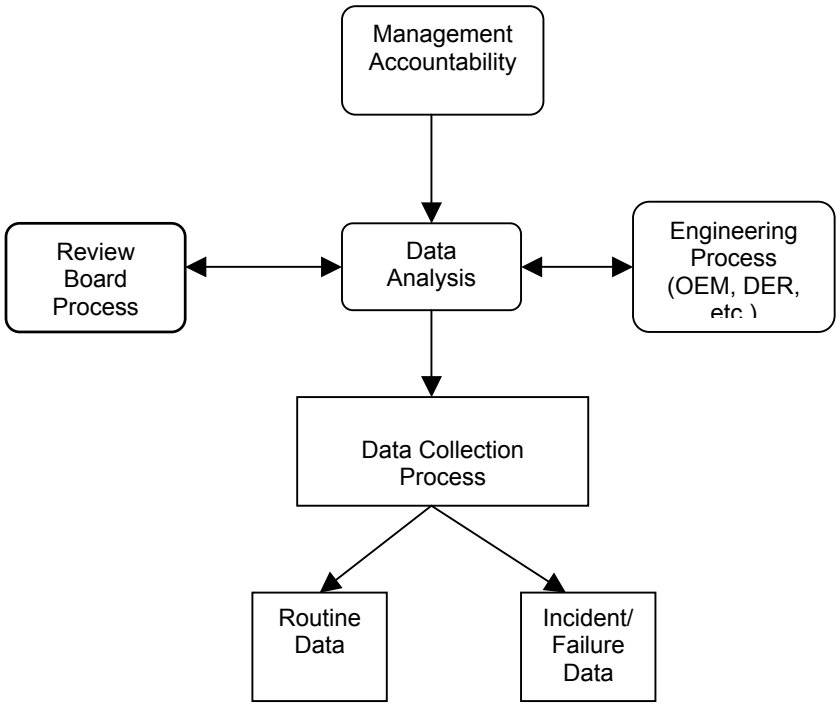


FIGURE 3. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM ANALYSIS PROCESS FLOWCHART

3. CHARACTERISTICS OF AN EFFECTIVE CASS.

3.1 MEASURING CASS EFFECTIVENESS.

An indirect measure of CASS effectiveness can be achieved through the verification that all elements of an air carrier's maintenance program are performing in accordance with the regulations. Certain indicators, such as adverse trends, premature failures, and maintenance-related flight cancellations and/or delays, may be indicative of degradation in one or more portions of the air carrier's maintenance program. It is important to note that the absence of problems within an air carrier's maintenance program does not necessarily mean that the air carrier's CASS is effective. However, the air carrier's CASS should identify any such problems if they are present.

An effective CASS should function through continuous surveillance, by collecting information, and by analyzing and validating the air carrier's operation. This includes, but is not limited to:

- Maintenance time limits
- Maintenance procedures
- Maintenance methods
- Maintenance techniques
- Maintenance practices

Each documented aircraft discrepancy must be reviewed. CASS focuses on analyzing and correcting the portion of the air carrier's maintenance program that allowed the program

performance discrepancy to occur. CASS would identify what caused a component to fail in the first place. To arrive at such an answer, CASS continuously reviews pilot report data, failure analyses, previous inspection findings, component removal rates, and teardown findings. These indicators can permit the air carrier to identify rogue or suspected unapproved parts and to direct maintenance and repair activity. Each CASS should also have procedures for documenting, reporting, and analyzing

- inspection findings
- operational malfunctions
- abnormal operations
- special inspections such as hard or overweight landings

A useful way to measure CASS effectiveness, from a senior management point of view, is to periodically review operational performance. This may include, for example, a review of summaries and trends identified by the CASS. Air carrier senior management personnel can supplement their review of monthly reports through interaction at various group meetings such as reliability boards, delays and cancellations meetings, and CASS meetings.

3.2 MINIMUM CASS ELEMENTS.

There are many variations on CASS elements among air carriers. While some of these differences relate to the size and scope of the air carrier's operations, some basic characteristics of effective CASS elements have been identified through industry surveys and through consultations with FAA inspectors who work with air carrier CASS elements day-to-day (see table 1).

TABLE 1. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM ELEMENTS

Minimum CASS Elements	Characteristics
People	Regardless of the complexity of organizations, operators should ensure the responsible manager, other management, and technical personnel are competent and with the authority to conduct operations at the highest level of safety.
Procedures	There should be documented procedures covering: • Auditing/surveillance analysis • Controls • Corrective action • Follow-up of corrective actions • Process measurements • Interfaces
Materials	There should be documented procedures to ensure company materials meet CASS requirements; for example: • Surveillance/audit recording materials • Auditor training materials • Analysis training materials

TABLE 1. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM ELEMENTS
(Continued)

Minimum CASS Elements	Characteristics
Tools	The air carrier should identify the tools used by CASS personnel to accomplish their tasks, such as: • Comprehensive audit checklists • Computers • Specialized computer software • C.A.S.E.
Data and Equipment	These must be adequate and properly maintained to perform the intended tasks.
Facilities	These must be adequate and properly maintained to perform the intended tasks.
Software	Must be adequate and properly maintained to perform their intended functions. There should be a system of security to limit access and the ability to change any computer programs, based on documented procedures that identify those personnel with a need to know. Adequate backup procedures also need to be in place.
CASS Audits	The basic elements of an effective audit are: • Planning what needs to be done and when • Implementation • Reporting • Corrective action • Follow-up • Record retention
Auditing organization	An audit is a formal and systematic evaluation of evidence. As such, the auditing organization must be totally independent from the organizations being audited.

3.3 SCOPE OF AUDITS.

Audits should include observation and monitoring of the air carrier's maintenance activities as well as contracted maintenance providers. It is important that audits include heavy maintenance checks instead of daily records reviews. While it may not be possible to review every record card from a large aircraft, such as D-check, auditors should carefully review nonroutine items accomplished during the check because these items were not included in the original planned check and may reveal deficiencies in the air carrier's CAMP.

3.4 AUDITOR QUALIFICATIONS.

Although there are no specific regulatory requirements that outline training and qualification requirements for CASS personnel, the air carrier should specify its requirements for selection, training, and experience of these individuals. The process should be clearly documented within the air carrier's manual system. An example of such a document may be a company training manual.

The qualifications of audit personnel may vary, but each air carrier should ensure that their audit personnel are competent and qualified. Whatever standard the air carrier chooses for its auditing personnel, they should possess the proper auditing skills and aviation maintenance knowledge to accomplish this function. The emphasis should be on competency, which may be achieved through a variety of training areas including, but not limited to:

- Technical
- Auditing techniques
- C.A.S.E.
- ISO 9000/2000
- AS 9100
- Six Sigma

Auditors should undergo initial and recurrent training in these areas to ensure they are up to date on the latest industry practices.

3.5 ANALYST QUALIFICATIONS.

Personnel who are responsible for CASS-related analysis should also be competent and appropriately qualified. They should undergo training in analysis techniques such as:

- Root cause analysis
- Risk analysis
- Systems analysis
- Human factors
- System safety concepts

It would also be preferable that air carrier analysts have a background in aviation to complement their theoretical knowledge with real-world experience.

3.6 ROLE OF OUTSIDE AUDITORS.

There are no restrictions on air carriers using individuals outside the company to conduct CASS audits. An example of such a system is C.A.S.E., which can serve as a supplement to the air carrier's processes. The FAA authorizes the use of C.A.S.E. audits during the issuance of Operations Specifications to each air carrier.

That said, the air carrier can never delegate CASS responsibility. C.A.S.E. is not a substitute for the air carrier's CASS audit function. It is intended to augment, but not to replace CASS, regardless of the air carrier's size.

Audits conducted by outside entities need to be specific to the needs of the company. For example, they should verify that vendors are using the contracting air carrier's company manuals, procedures, or maintenance programs rather than merely verifying that a vendor is following accepted industry practices consistent with 14 CFR. Therefore, any time an air carrier contracts with outside auditors, it must ensure these auditors are appropriately trained. These

auditors should possess the same competency and use the same procedures and checklists, as the air carrier's own auditors.

Once the air carrier's personnel receive the results of outside auditor's surveillance activities, these must be evaluated. Otherwise, the air carrier cannot follow-up on the discrepancies. There should be no distinction between findings made by a company auditor and those made by an outside auditor. All findings must be treated with the same degree of importance.

3.7 ADEQUATE RESOURCES.

The air carrier's ability to provide adequate resources for its CASS in addition to its operations and maintenance programs deserves particular attention during periods of growth or change. This may be particularly noticeable in the area of QA. Many air carriers support their expanded activities through the outsourcing of maintenance to other air carriers or repair stations. While contracted maintenance facilities are legally responsible for all work they accomplish, they may subcontract work to facilities that do not possess FAA certificates or ratings. Ultimately, each air carrier is primarily responsible for the airworthiness of its aircraft and must recognize that the dispersal of maintenance work to other contracted facilities puts additional pressures on the air carrier's CASS auditing functions. Therefore, air carriers should ensure that their CASS functions have adequate resources to accomplish increased surveillance and analysis functions.

3.8 VOLUNTARY DISCLOSURES.

Voluntary disclosures by air carriers with VDRPs are one way to measure CASS effectiveness. The VDRP process may be used to disclose incidences of regulatory noncompliance discovered as a result of a CASS function. Previous voluntary disclosure cases should be reviewed by the CASS so adverse trends can be identified.

Air carrier managers should not be discouraged to see an increase in voluntary disclosures as a result of changes they may make to their CASS elements intended to enhance them. An increase in voluntary disclosures does not necessarily mean that there are systemic problems at an air carrier, as long as the number of voluntary disclosures decreases over time while the CASS enhancements take effect.

4. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM MODELS.

In this section, three models will illustrate how a CASS might be implemented at air carriers based on varying size and complexity. A model CASS, as described here, represents an acceptable system rather than an idealized or best possible system. Air carriers can adopt these models as the basic framework for their CASS elements, or for comparison with their existing CASS to ensure it includes the required and recommended elements.

While the CASS for an air carrier will still have the same functional areas as the general CASS described in section 2, these models show how the same overall system will vary based on operator requirements. These models are intended to show how CASS elements can vary among air carriers and still meet regulatory requirements. These elements are formal programs that air carriers use to achieve particular goals. Some of them are required by 14 CFR and others have

been developed by industry, or in partnership with the FAA, to enhance the efficiency and/or safety of air carrier operations.

It should be noted that since the publication of 14 CFR Part 119, a majority of scheduled Part 135 certified air carriers converted to Part 121 certificates. Therefore, the distinction between Parts 135 and 121 operators has changed. For example, some Part 135 operators are bigger than some smaller Part 121 operators. As a result, air carriers should tailor their CASS based on the size and complexity of their operations rather than on whether they hold a Part 121 or Part 135 certificate.

4.1 CASS MODEL 1: LARGE 14 CFR PART 121 AIR CARRIER.

This model is representative of a Part 121 air carrier with more than 100 turbine-powered aircraft operating worldwide. Such an air carrier has the most complex programs as well as commensurate resources. For example, this air carrier has elected to implement an overall IEP that oversees all its operations, including CASS itself.

Overall responsibility for CASS at this air carrier lies with the VP of Maintenance who delegates the authority to implement and maintain the CASS to the Director of QA who, in turn, heads a QA department that has a large staff of auditors and analysts.

4.1.1 Surveillance.

QA conducts external audits of the air carrier's maintenance providers and internal audits of the air carrier's functions. The air carrier is a member of C.A.S.E. and performs audits for the air carrier and the information is provided to the C.A.S.E. organization. C.A.S.E. audits performed by other air carrier's auditors for a particular vendor are reviewed and significant findings are followed up by the air carrier's own auditors.

4.1.2 Controls.

The air carrier has implemented an IEP to serve as a control over its CASS to ensure that CASS continues to meet the goals established by the regulations.

4.1.3 Analysis.

QA conducts the analysis of their surveillance data and provides reports to upper management through periodic reports. A reliability department collects and analyzes mechanical performance data and reports directly to the air carrier's CASS review board (CRB). The CRB is comprised of the director of QA (who acts as a chairperson), the director of reliability, the director of quality control (QC), and the director of line maintenance. The CRB has the authority to make changes to the air carrier's maintenance programs based on the analysis of performance data.

4.1.4 Corrective Action.

Personnel from each affected department or area are responsible for the investigation, evaluation of, and the development of responses to the audit findings to prevent a recurrence. QA then

reviews and approves the resulting corrective action plans. QA auditors are responsible for approving the responses to these findings as well as ensuring their proper implementation. The air carrier's procedures specify that CASS audits should not result in transferring the responsibility for achieving the desired outcomes from the operating organization to the auditing organization.

The air carrier ensures that effective communication exists regarding findings that may affect more than just the area where an audit revealed a problem. This air carrier uses team-created action plans to develop corrective actions. This method is effective where deficiencies may cover several departments or areas.

In order to include all affected parties in the corrective action development process, the air carrier uses corrective action teams. The air carrier's written procedure describes the role of the reliability analysis, engineering department, and reliability control board in the process.

4.1.5 Follow-Up.

The air carrier uses an automated system to monitor corrective actions to CASS findings and has detailed procedures in place that describe how corrective actions are monitored, including how follow-up is accomplished.

The air carrier sets a length of time for corrections and categorizes them according to their severity. A finding that could result in an immediate safety issue requires immediate action, while others that may be precursors to an event are given 30 to 60 days for a corrective action to be implemented.

4.1.6 Example.

To illustrate how this air carrier's CASS works, consider an example of how a problem in the air carrier's CAMP is identified and addressed under its system. The initiating problem is a rash of hydraulic pump leaks identified through the air carrier's computerized reliability program, which shows too many delays and too many MISs and service difficulty reports related to the pump leaks. During a reliability meeting, this trend is discussed and all parties agree that an investigation is warranted to determine the reason behind the failures. The investigation generates an engineering process review of the failures by the engineering department.

The engineering process review concludes that the hydraulic pump failures are the result of an error in the way the pumps were overhauled. A sealant used in the pumps' repair was the wrong type, which led to the premature failure of the pumps. QA auditors then evaluate whether the pumps were overhauled in-house or whether they were sent out for overhaul. It was determined that a single repair station overhauled all the failed pumps.

QA auditors then conduct a special audit of the contracted repair station and discover an error in the repair station's procedures. A service bulletin for a different type of pump that called for the new sealant was incorrectly applied to the air carrier's pumps. The auditor's evaluation of the mistake concludes that a clerical error caused the service bulletin to be incorporated into the overhaul procedures for the wrong pump. The repair station implements a quality control review

of such changes by qualified personnel to avoid a recurrence of the problem. The air carrier's QA auditors approve this corrective action plan.

Once the contracting repair station implements the corrective action, QA auditors conduct an audit of the air carrier's own shop to ensure that the same mistake is not repeated there. Finally, QA auditors establish a schedule to monitor the subcontracted repair station and ensure the comprehensive fix proposed by the facility's managers is effective.

4.1.7 Summary.

Figure 4 shows a process functional diagram for the air carrier described in model 1. It includes, in the shaded areas, one example of the organizational responsibilities within the air carrier that are tasked with correct implementation of an effective CASS. The diagram should not be viewed as an organizational chart; the colored areas show which individuals or departments may be assigned responsibility for the CASS functions within varying air carrier operations.

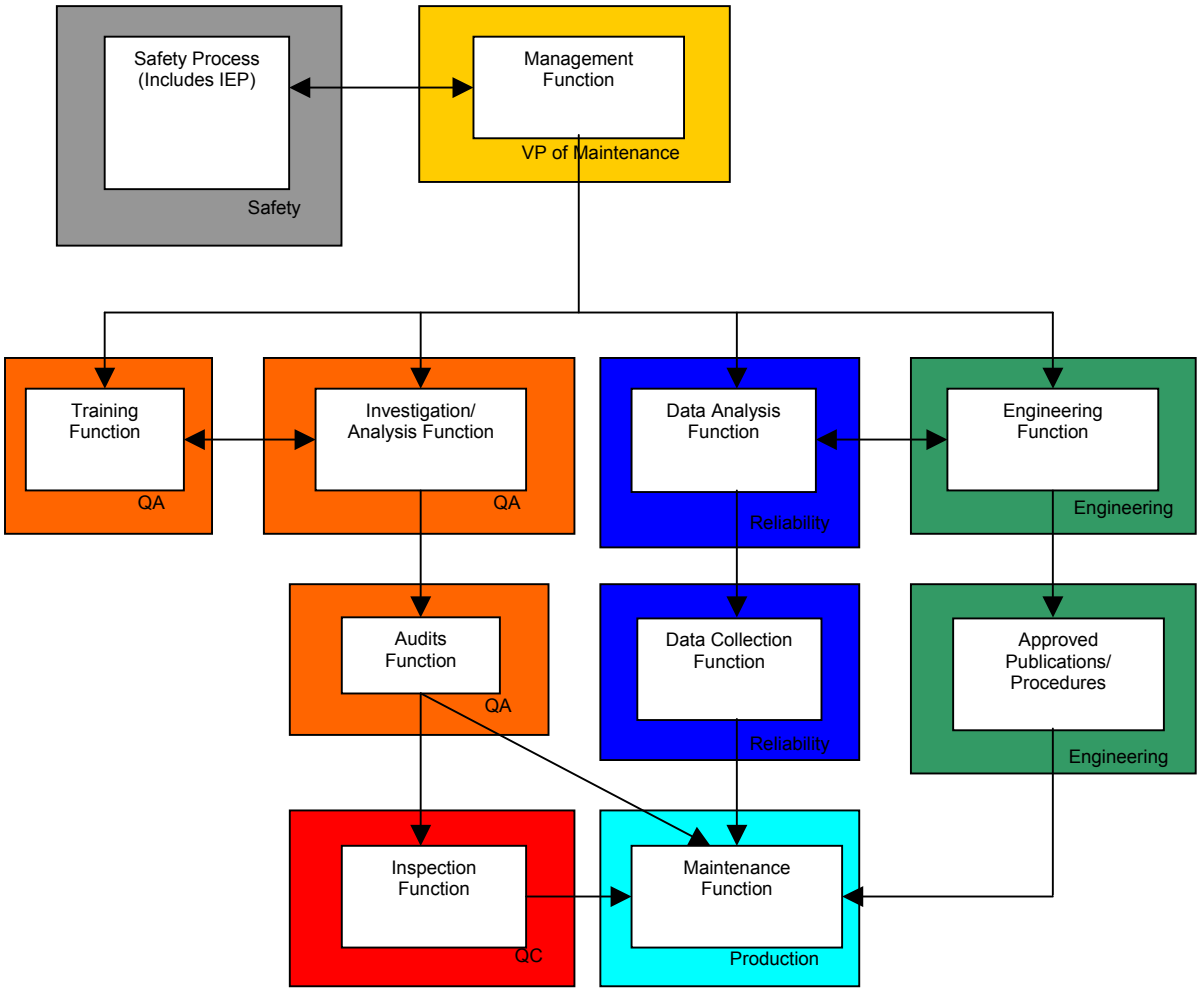


FIGURE 4. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM PROCESS FUNCTIONAL DIAGRAM FOR CASS MODEL 1

4.2 CASS MODEL 2: MEDIUM 14 CFR PART 121 OR LARGE PART 135 AIR CARRIER.

This CASS model applies to an air carrier that operates 5 to 20 turbine-powered aircraft under Part 121 or 135, as applicable, in a domestic regional network. Such an air carrier may be affiliated with a major air carrier and has adequate resources, but it may not find it necessary to develop or adopt many of the programs found at the larger air carriers such as those addressed in CASS model 1.

For example, the air carrier does not have a separate QA department, but instead, QC accomplishes all CASS functions. Senior management, which is responsible for CASS, delegates the daily operation of CASS elements to the chief inspector, who heads QC.

4.2.1 Surveillance.

CASS audits are accomplished by the air carrier's QC department using QC personnel as well as personnel from other departments who are borrowed for some audits. The air carrier has written procedures that specify auditors who are borrowed in this fashion cannot audit the departments in which they work on a full-time basis in order to preserve their impartiality.

4.2.2 Controls.

The air carrier has a safety department that serves as a separate control over the safety of the air carrier's operations. The air carrier also contracts with external auditors from time to time to review their operations and provide feedback on the air carrier's CASS to the air carrier's management.

4.2.3 Analysis.

Auditors themselves perform the analysis of their audit findings. The QC department has trained analysts that collect mechanical performance data, but the air carrier uses the aircraft OEM as the repository for the data.

4.2.4 Corrective Action.

Personnel from each affected department or area are responsible for the investigation and evaluation of audit findings, as well as the development of responses to the findings to prevent a recurrence. QC then reviews and approves the resulting corrective action plans. Company auditors are responsible for the approval of responses to these findings as well as for ensuring their proper implementation.

The air carrier ensures that effective communication exists regarding findings that may affect more than just the area where an audit revealed a problem. The air carrier also uses team-created action plans to develop corrective actions. This method is effective where deficiencies may involve several departments or areas that may require that more complete corrective action be developed.

In order to include all affected parties in the process of corrective action development, the air carrier uses corrective action teams. The air carrier's written procedures describe the role of QC in the process.

4.2.5 Follow-Up.

The air carrier uses an automated system to monitor corrective actions to CASS findings and has detailed procedures in place that describe how corrective actions are monitored, including how follow-up is accomplished.

The air carrier sets a length of time for corrections and categorizes them according to their severity. A finding that could result in an immediate safety issue requires immediate action, while others that may be precursors to an event are given 30 to 60 days to implement a corrective action.

4.2.6 Example.

To illustrate how this air carrier's CASS works, consider an example of how a problem in the air carrier's CAMP is identified and addressed. The initiating problem is a rash of hydraulic pump leaks identified by the QC personnel in reviewing the air carrier's computerized data on the pump OEM's computerized data system. During a reliability meeting, this trend is discussed and all parties agree that an investigation is warranted to determine the reason for the failures. QC analysts correspond with the pump's OEM to determine why the failures are occurring.

The OEM's engineers conclude that the hydraulic pump failures are the result of an error in the way the pumps were being overhauled. A sealant used in the pumps' repair was the wrong type, which led to the premature failure of the pumps. QC auditors then evaluate whether the pumps were overhauled in-house, or whether they were sent out for overhaul. It was determined that a single repair station overhauled all the failed pumps.

QC auditors then conduct a special audit of the contracted repair station and discover an error in the repair station's procedures. A service bulletin for a different type of pump that called for the new sealant was incorrectly applied to the air carrier's pumps. The auditor's evaluation of the mistake concludes that a clerical error caused the service bulletin to be incorporated into the overhaul procedures for the wrong pump. The repair station implements a quality control review of such changes by qualified personnel to avoid a recurrence of the problem. The air carrier's QC auditors approve this corrective action plan.

Once the contracting repair station implements the corrective action, QC auditors conduct an audit of the air carrier's own shop to ensure that the same mistake is not being repeated there. Finally, QC auditors establish a schedule to monitor the subcontracted repair station and ensure the comprehensive fix proposed by the facility's managers is effective.

4.2.7 Summary.

This air carrier has a VDRP but does not incorporate some other voluntary programs and elements into its overall CASS. For example, it has no reliability program, no QA department,

and no IEP. While none of these are required, the air carrier may implement such programs in the future.

Figure 5 shows a process functional diagram for the air carrier described in model 2. It includes the organizational functions within the air carrier that result in the correct implementation of an effective CASS. The diagram should not be viewed as an organizational chart, but the colored areas show which individuals or departments are assigned responsibility for the CASS functions.

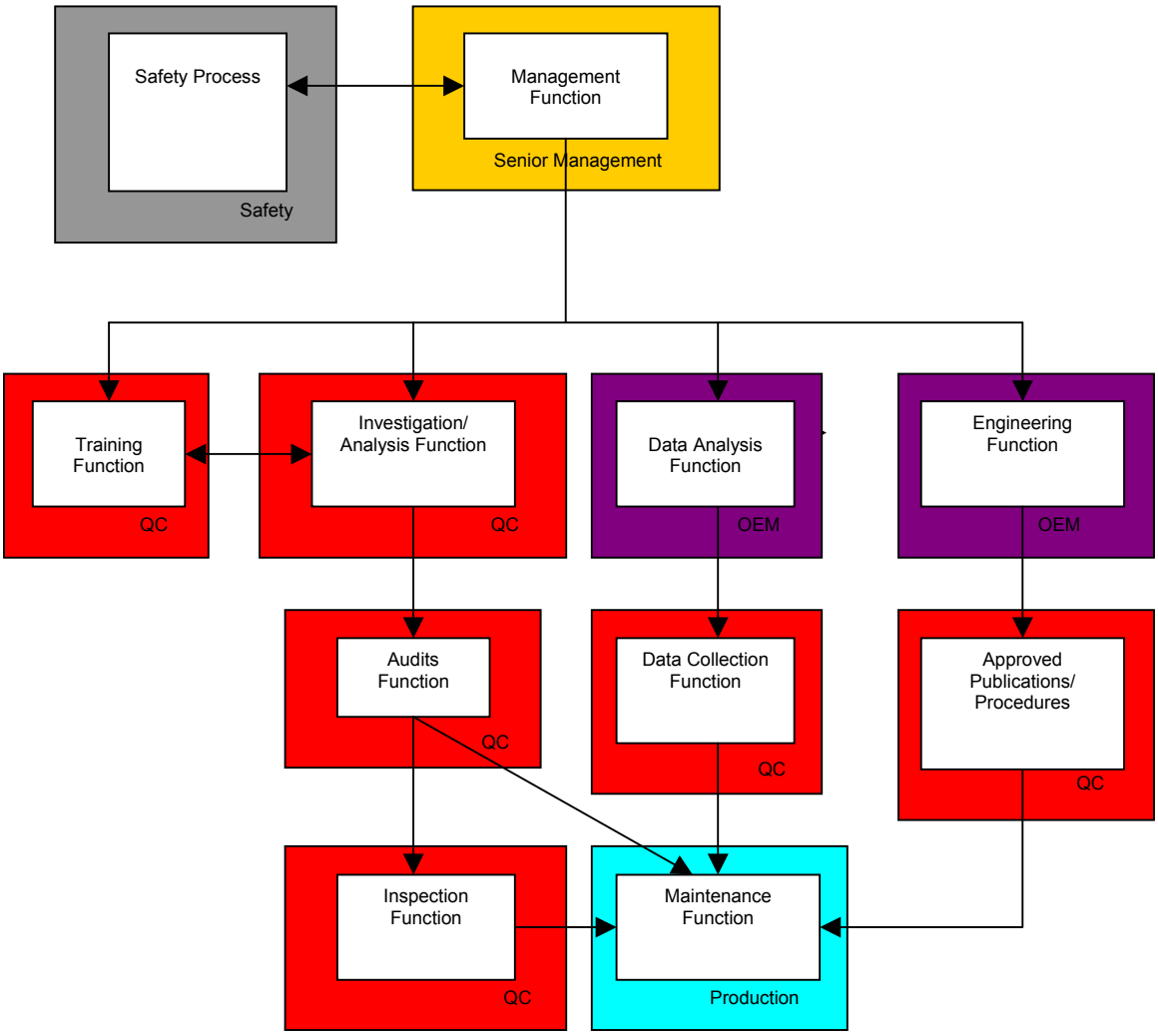


FIGURE 5. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM PROCESS FUNCTIONAL DIAGRAM FOR CASS MODEL 2

4.3 CASS MODEL 3: 14 CFR PART 135 AIR CARRIER.

In this CASS model, the air carrier has fewer than five aircraft that have ten or more seats that it operates on demand under Part 135. Such an air carrier represents the opposite end of the spectrum from that of CASS model 1. Resources are limited, so that often a single individual is responsible for several CASS functions.

While the president, or responsible manager, of the company is responsible for the air carrier's CASS, the authority to make changes to its CASS is delegated to QC. QC may be comprised of a single person or it may be a department that is responsible for the day-to-day operation of CASS elements.

4.3.1 Surveillance.

The air carrier may or may not contract out its maintenance. This may be contracted to a variety of providers, including another air carrier or a certificated repair station. A delegated person within the company sets the schedule of audits and compiles the reports for submission to the air carrier's president or responsible manager. The air carrier also contracts out its CASS surveillance activities to an outside entity that reports its results to the responsible manager.

4.3.2 Controls.

The air carrier has a safety officer that serves as a separate control over the safety of the air carrier's operations. The air carrier also contracts with external auditors from time to time to review their operations and provide feedback on the air carrier's CASS to the air carrier's president.

4.3.3 Analysis.

The majority of the analysis functions of CASS are accomplished by personnel from several departments who review and analyze data as part of regular weekly or monthly meetings between maintenance, operations, and senior management personnel.

Mechanical performance data analysis is accomplished through an independent data collection and analysis system to monitor the condition of aircraft, engines, and components.

4.3.4 Corrective Action.

The air carrier has specific written procedures to process CASS audit and analysis findings. Otherwise, if responses to CASS findings were developed and implemented informally, corrective actions would be less standardized, more difficult to track, and would rely too much on corporate memory.

4.3.5 Follow-Up.

Follow-up on audit findings is tracked using an automated system, which is essentially an off-the-shelf database program. The responsible manager uses established timelines for closing out findings and ensuring audit findings are addressed.

4.3.6 Example.

To illustrate how this air carrier's CASS works, consider an example of how a problem in the air carrier's CAMP was identified and addressed. The initiating problem is a rash of hydraulic pump leaks identified by the chief inspector in reviewing the air carrier's computerized data on

the pump OEM's computerized data system. During a meeting with the president, this trend is discussed and they agree that an investigation is warranted to determine the reason behind the failures. The inspectors then correspond with the pump's OEM to determine why the failures are occurring.

The OEM's engineers conclude that the hydraulic pump failures are the result of an error in the way the pumps were overhauled. A sealant used in the pumps' repair was the wrong type, which led to the premature failure of the pumps. The inspectors then evaluate whether the pumps were overhauled in-house or whether they were sent out for overhaul. It was determined that a single repair station overhauled all the failed pumps.

The inspectors then contracted with an outside organization to conduct a special audit of the contracted repair station. As a result, they discover an error in the repair station's procedures and describe in a report to the inspectors that a service bulletin for a different type of pump that called for the new sealant was incorrectly applied to the air carrier's pumps. The outside organization's evaluation of the mistake concludes that a clerical error caused the service bulletin to be incorporated into the overhaul procedures for the wrong pump. Based on this finding, the repair station implements a quality control review of such changes by qualified personnel to avoid a recurrence of the problem. This corrective action plan is approved by the air carrier's inspectors, and they agree to continue sending hydraulic pumps to the repair station in question.

Once the contracting repair station implements the corrective action, the inspectors establish a schedule to monitor the subcontracted repair station and ensure the comprehensive fix proposed by the facility's managers is effective.

4.3.7 Summary.

This air carrier has chosen not to incorporate any of the voluntary programs and processes into its overall CASS. For example, it has no reliability program, no QA department, no VDRP, and no IEP. While none of these are required, the airline may benefit from some programs, while others are clearly not necessary for such a small organization.

Figure 6 shows a process functional diagram for the air carrier described in model 3. It includes the organizational functions within the air carrier that result in the correct implementation of an effective CASS. The diagram should not be viewed as an organizational chart, but the colored areas show which individuals or departments are assigned responsibility for the CASS functions.

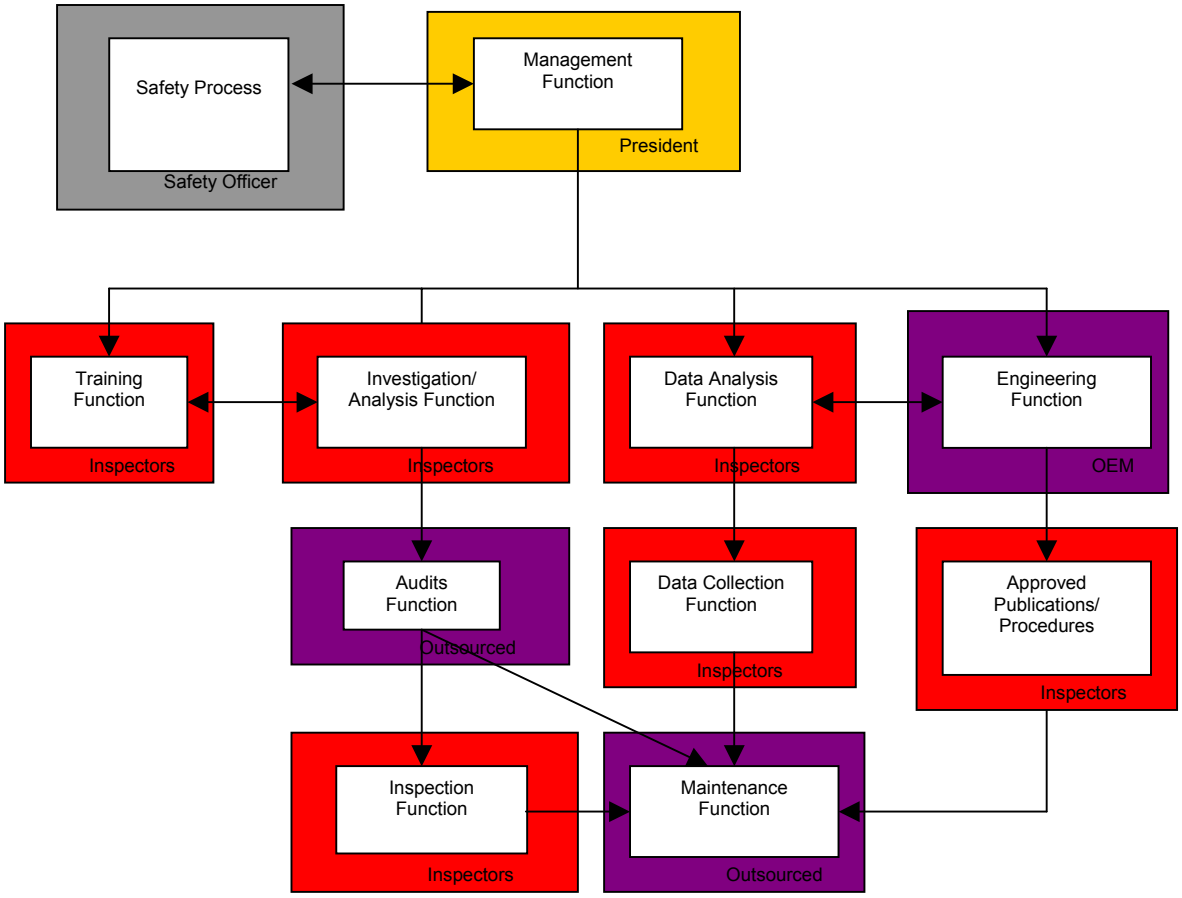


FIGURE 6. CONTINUING ANALYSIS AND SURVEILLANCE SYSTEM PROCESS FUNCTIONAL DIAGRAM FOR CASS MODEL 3

5. RELATED DOCUMENTATION.

For more information on human factors, readers are encouraged to visit the FAA's web site dedicated to human factors at http://hfskyway.faa.gov.

Another example of a risk analysis/assessment matrix and associated terminology is the System Safety Process (and the associated process steps) in the FAA's Safety Risk Management Order 8040.4. This document and the chapter on the System Safety Process and a Risk Assessment Matrix can be found at http://www.asy.faa.gov/Risk/SSProcess/SSProcess.htm.

For additional information on CASS and related information presented in this model, please see the following sources.

- Continuing Analysis and Surveillance System (CASS) Comprehensive Research Report for the Development of a CASS Model, July 15, 2002, FAA Risk Analysis Branch, AAR–490, Contract No. DTFA01-98-C00069, Project Code 3011-241.

- The Continuing Analysis and Surveillance System, The FAA Inspector's Perspective, May 17, 2002, Volpe National Transportation Systems Center, Contract No. DTRS57–99–D–00055, to 19.

- Air Carrier Internal Evaluation Model Program Guide, February 1992, U.S. Department of Transportation, Contract No. DTFA01-88-C-00064, Work Order No. 8.

- National Program Review Summary Report, December 8, 2000, FAA, Flight Standards Service.

- Report on Oversight of Aircraft Maintenance, Continuing Analysis and Surveillance Systems, Report No. AV–2002–066, December 12, 2001, U.S. Department of Transportation, Office of the Secretary of Transportation, Office of the Inspector General (OIG).

- United States General Accounting Office, Government Auditing Standards, Amendment 2, July 1999.

- National Intergovernmental Audit Forum, How to Avoid Substandard Audits, May 1988.

- Title 14 Code of Federal Regulations (CFR) Parts 119, 121, and 135.

- FAA Order 8300.10*,* Airworthiness Inspector's Handbook.

- AC 00-58, Voluntary Disclosure Reporting Program.

- AC 00-46, Aviation Safety Reporting Program*,* February 26, 1997.

- AC 120-16, Continuous Airworthiness Maintenance Programs.

- AC 120-59, Air Carrier Internal Evaluation Programs, October 26, 1992.

- AC 120-66, Aviation Safety Action Program, March 17, 2001.

- Safety Attribute Inspection Job Aid, Element 1.3.11, Continuous Analysis and Surveillance.

- International Civil Aviation Organization Circular 253-AN/151, Human Factors Digest No. 12*,* Human Factors in Aircraft Maintenance and Inspection, 1995.

6. CONCLUDING REMARKS.

All air carriers are required by the Title 14 Code of Federal Regulations (CFR) Parts 121.373 and 135.431 to conduct continuous evaluations of their maintenance programs by establishing and implementing a Continuing Analysis and Surveillance System (CASS). However, the sparse

language in the regulation governing CASS provides little guidance on how to establish and implement an effective CASS.

This report discusses the regulatory requirement and recommends practical guidance for establishing and implementing CASS. Through the study of the language and intended purpose of the regulatory requirement, as well as inputs from industry and FAA personnel, three structured and methodical CASS models were developed based on the size, resource, and complexity of three typical groups of air carriers.

- Model 1: For large 14 CFR Part 121 air carriers with more than 100 turbine-powered aircraft operating worldwide

- Model 2: For medium 14 CFR Part 121 or large Part 135 air carriers with 5 to 20 turbine-powered aircraft operating in a domestic regional network

- Model 3: For small 14 CFR Part 135 air carriers with less than five aircraft that have ten or more seats operating on demand

In developing these models, many factors on the fundamentals, functions, and characteristics of CASS were analyzed and considered. Each model represents a complete system that should meet, or exceed, the regulatory requirements and on which new entrant air carriers can base their CASS. Existing air carriers can also use the models as a comparison to their existing CASS and determine its effectiveness.

The research results in this report should help clarify and assist industry personnel and FAA inspectors in complying with the CASS requirement.